Inference on geochemical reactions to control the pore fluid and gas properties in the southern Ulleung Basin

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During the 2016 Expedition in the southern Ulleung Basin of East Sea, we collected pore fluid and gas samples from five sites (core length < 8 m) displayed two different seismic features (chimney and non-chimney). The depth of sulfate-methane transition zone (SMTZ) is less than 4.5 meters below seafloor (mbsf) at all sites and shallower at the chimney than non-chimney sites. In addition, $\delta^{13}C_{CH4}$ values around the SMTZ are enriched at the chimney sites compared to non-chimney sites, indicating higher methane flux at the former than the latter. Concentration of alkalinity, NH_4^+, and PO_4^{3-} increases with depth due to the organic matter degradation by particular organic matter sulfate reduction (POCSR), anaerobic oxidation of methane (AOM), and methanogenesis (ME). However, the maximum alkalinity and the minimum $\delta^{13}C_{DIC}$ around the SMTZ are higher than 60 mM and -28.3‰, respecteively, and that Mg^{2+} concentration has a greater than that of seawater (~55 mM), which cannot be explained by those biogeochemical reactions. These results are associated with upwardly high $\delta^{13}C$-riched DIC flux produced by ME below the SMTZ and the silicate weathering coupling with ME occurred at the anoxic sediment column. We also observed several methane-derived authigenic carbonates (MDACs) as a form of nodules with irregular morphology, whose $\delta^{13}C$ ranges from -49.9‰ to -31.3‰, and enriched Cl^- concentration (> 550 mM) in pore fluid at the chimney sites, which are indirect evidences for the gas hydrate existence. Overall, we postulated that the properties of pore water, gas, and MDACs in the southern Ulleung Basin reflect the complex biogeochemical and inorganic geochemical reactions.